



New records of cave-inhabiting Gerromorpha (Insecta, Hemiptera, Heteroptera) from Brazil

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Abstract

Based on material collected in Brazilian caves, new records are presented for seven species of Gerromorpha (Insecta, Hemiptera, Heteroptera) belonging to the families Gerridae [*Brachymetra albinervus* (Amyot & Serville, 1843); *Cylindrostethus palmaris* Drake & Harris, 1934], and Veliidae [*Microvelia ioana* Drake & Hottes, 1952; *Paravelia digitata* Rodrigues & Moreira, 2016; *Rhagovelia henryi* Polhemus, 1997; *R. robusta* Gould, 1931; *R. whitei* (Breddin, 1898)]. Illustrations and notes on identification and habitat are presented for all species above.

Keywords

Cave insects, geographical distribution, Neotropical Region, semiaquatic bugs, South America, subterranean fauna

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Introduction

The infraorder Gerromorpha (Insecta, Hemiptera, Heteroptera) comprises more than 2100 species of semiaquatic bugs found mainly on the margins or the surface of water bodies around the world, except for Antarctica, and it is the dominant group of insects in these environments (Andersen 1982; Polhemus and Polhemus 2008). These animals play an important role in freshwater environments, and knowledge about them is essential for the study of aquatic biology and the proper management of hydric resources (Moreira 2015).

The Brazilian fauna of Gerromorpha has been the target of many taxonomic and faunistic studies, especially

during the last 30 years, but large areas of the country remain unexplored (Polhemus and Polhemus 2007, 2008; Moreira et al. 2011, 2018). In addition, certain types of environments, like hygropetric habitats and plant-held waters, have been poorly sampled even by specialists (Moreira et al. 2011).

The aim of the present study is to provide new information on the geographic distribution of Gerromorpha in Brazilian caves, which only recently revealed to house a remarkable diversity of semiaquatic bugs (Moreira and Campos 2012; Taylor and Ferreira 2012; Rodrigues et al. 2014; Cordeiro and Moreira 2015; Floriano and Moreira

2015; Rodrigues and Moreira 2016a, 2016b; Polhemus and Ferreira 2018; Rodrigues and Álvarez-Arango 2019; Monte and Bichuette 2020).

Methods

Sampled caves are located in the Brazilian states of Bahia (northeastern region), Mato Grosso (central-western), Minas Gerais, São Paulo (southeastern), and Santa Catarina (southern) (Fig. 1). Permits for the collections were provided to MEB by the Instituto Chico Mendes de Conservação da Biodiversidade (processes 20165 and 20296-7). Specimens were collected manually or with the aid of hand nets by MEB and her team, then fixed and preserved in 70% ethanol. Material examined is deposited in the collection of the Laboratório de Estudos Subterrâneos, Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, São Carlos, Brazil (LES).

Specimens were identified mainly by using the descriptions and keys provided by Polhemus (1997), Floriano et al. (2016), Magalhães et al. (2016), and Rodrigues and Moreira (2016a). In the case of *Brachymetra* Mayr, 1865, specimens were also compared with reference material. Stacked multifocal digital photographs were obtained using the Leica Application Suite software and a Leica DMC 2900 camera attached to a Leica M205 C stereomicroscope.

Regardless of the sampled water bodies being completely subterranean (hydrogeological systems) or fed by

epigean drainages, the insects were observed feeding and reproducing in different portions of the caves. This indicates that there is maintenance of the subterranean populations and that these bugs can be considered troglobites, meaning that they are facultative cavernicolous, with populations inside and outside of subterranean habitats. A brief description of the sampling sites is presented below.

Gruta do Catão (-12.3686° , -044.8676° ; Fig. 2) is a cave located in the middle São Francisco river basin, in the Cerrado phytophysiognomy (savannah-like vegetation), and is inserted in the São Desidério karst area, part of Bambuí geomorphological unit. The cave is within a protected area, the Parque Municipal da Lagoa Azul, and has ca. 150 m of mapped passageways crossed by a small river formed by waters of the João Rodrigues hydrogeological system. Gruta do Catão is subject to touristic visitation; however, the tourists do not cross the river. Besides the river, some springs, which are perennial even in the dry season, are located close to the drainage.

Toca de Candeias (-11.0533° , -042.1158° ; Figs. 3, 4) is a cave located in the middle São Francisco river basin, in the semiarid region of Serra do Calcário (Una Group), central-northern Bahia state, northeastern Brazil. This limestone cave has about 250 m of mapped passageways (Grupo Pierre Martin de Espeleologia, pers. comm.) and is one of most important in the Serra do Calcário region. Toca de Candeias is totally flooded between November and February (rainy season), and during the rest of the

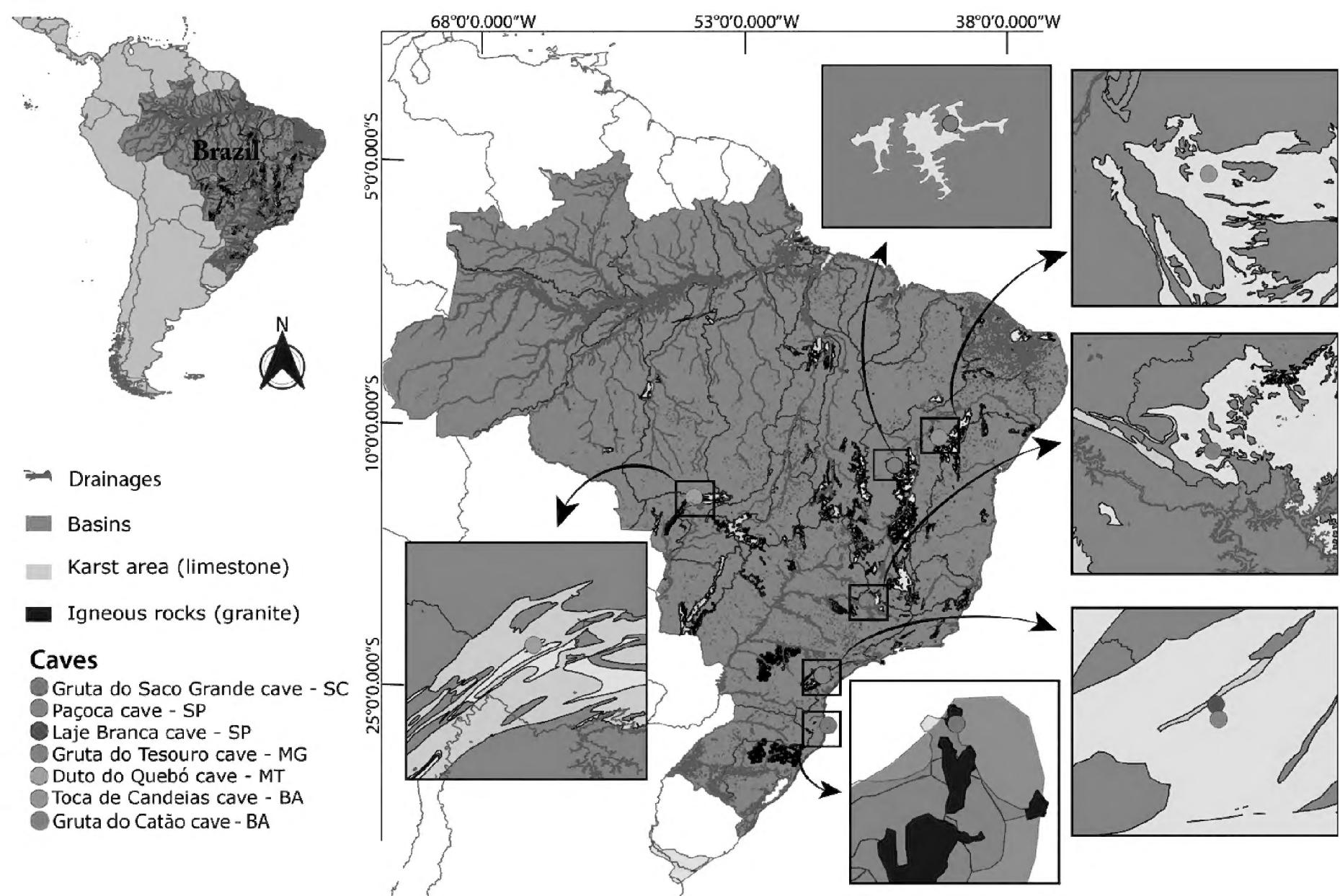


Figure 1. Map showing the location of the caves where the semiaquatic bugs were collected.



Figure 2. Gruta do Catão, São Desidério, Bahia state, Brazil. Photo by A. Lobo.



Figure 3. Karstic landscape surrounding Toca de Candeias, Central, Bahia state, Brazil. Photo by M.E. Bichuette.



Figure 4. Aquatic microhabitat inside Toca de Candeias, Central, Bahia state, Brazil. Arrows indicate the places on (blue) or adjacent to (white) the water where *Paravelia digitata* was observed. Photo by M.E. Bichuette.

year it is submitted to drastically dry weather. Besides, there is a perennial pool formed by phreatic water in the aphotic zone. There is no legal protection and the cave is threatened due to a reduction of annual precipitation in the region. Other threats are still potential, such as the possible extraction of limestone rock for cement production. Serra do Calcário region, including Toca de Candeias, is fundamental for the water supply of the local population and must be protected.

Duto do Quebó (-14.4447° , -056.0195° ; Figs. 5, 6) is a limestone cave with ca. 300 m of mapped passageways located in a Cerrado phytophysiognomy from the upper Paraguai river basin, Alto Paraguai karst area, Mato Grosso state, central-western Brazil. A medium-sized river crosses the main cave gallery, which is formed by a sandy bank mixed with boulders, pebbles, tree trunks, branches, and leaves brought in by floods. The cave is a touristic attraction, but apparently this activity has not a marked impact, since tourists cross the cave using buoys

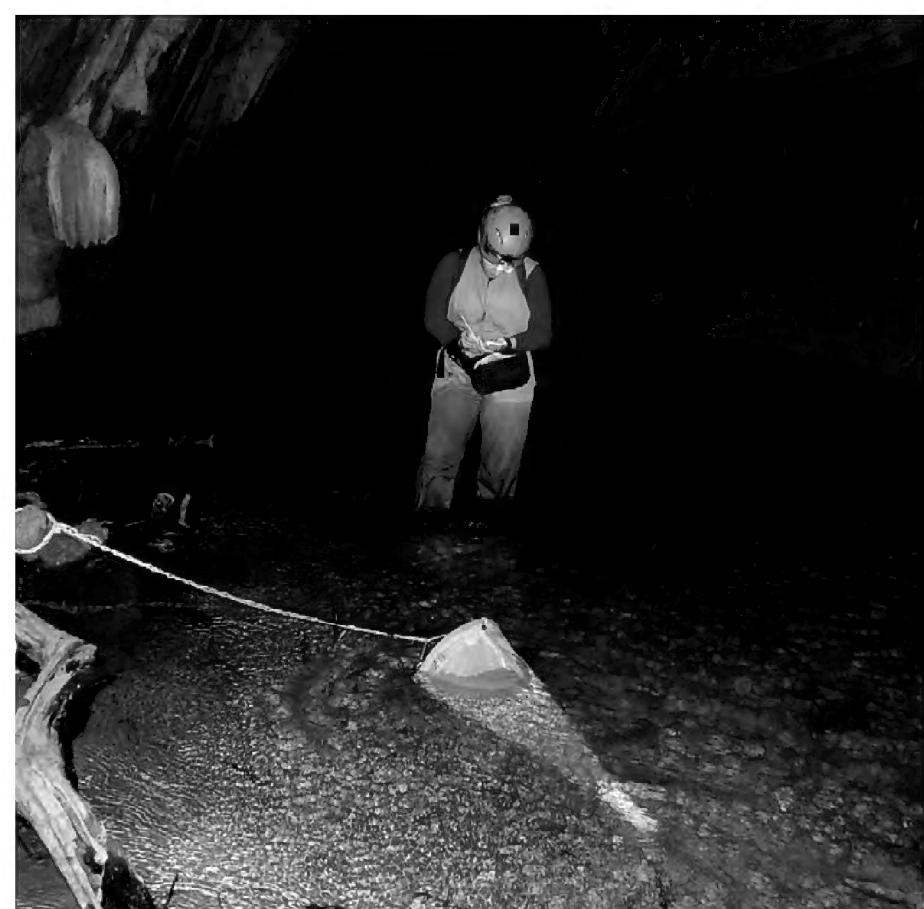


Figure 5. Duto do Quebó, Nobres, Mato Grosso state, Brazil. Photo by J.S. Gallo.



Figure 6. Resurgence outside Duto do Quebó, Nobres, Mato Grosso state, Brazil. Photo by A. Chagas-Júnior.

or boats, not touching the bottom of the river or substrates along the margins.

Gruta do Tesouro (-20.3655° , -046.2025° ; Fig. 7) is a limestone cave having an extent of ca. 1200 m (Grupo Bambuí de Pesquisas Espeleológicas, pers. comm.) located in the upper São Francisco river basin, São Roque de Minas, Serra da Canastra context (Bambuí Geomorphological Unit), Minas Gerais state, southeastern Brazil, in a Cerrado phytophysiognomy. The cave has many upper and lower level galleries, and a small stream crosses the main gallery. Gruta do Tesouro has no legal protection and is visited sporadically by tourists. The main threat to the cave and its fauna is the deforestation in the surroundings, which causes a decrease in the water volume, besides siltation of the river.

Caverna Laje Branca (-24.5492° , -048.7208° ; Fig. 8) is a limestone cave with ca. 650 m of mapped passageways located in the Alto Ribeira river basin, a karst area inserted in the Açuengui Geomorphological Unit,



Figure 7. Laboratório de Estudos Subterrâneos team collecting semiaquatic bugs inside Gruta do Tesouro, Piumhi, Minas Gerais state, Brazil. Photo by J.E. Gallão.



Figure 8. Caverna Laje Branca, Iporanga, São Paulo state, Brazil. Photo by D. Menin.

São Paulo state, in the Atlantic Rainforest domain. There are some small pools deep within the cave and a small stream close to the entrance, where the specimens were collected. The cave is located in the surroundings of the Parque Estadual Turístico do Alto Ribeira (PETAR), in a privately owned area, and has no legal protection. This cave is sporadically visited by tourists and has no management plan for this activity, which implies impacts on the local fauna.

Caverna Paçoca (-24.5658° , -048.7167° ; Fig. 9) is a limestone cave with ca. 600 m of mapped passageways (Grupo Pierre Martin de Pesquisas Espeleológicas, pers.



Figure 9. Caverna Paçoca, Iporanga, São Paulo state, Brazil. Photo by P.P. Rizzato.

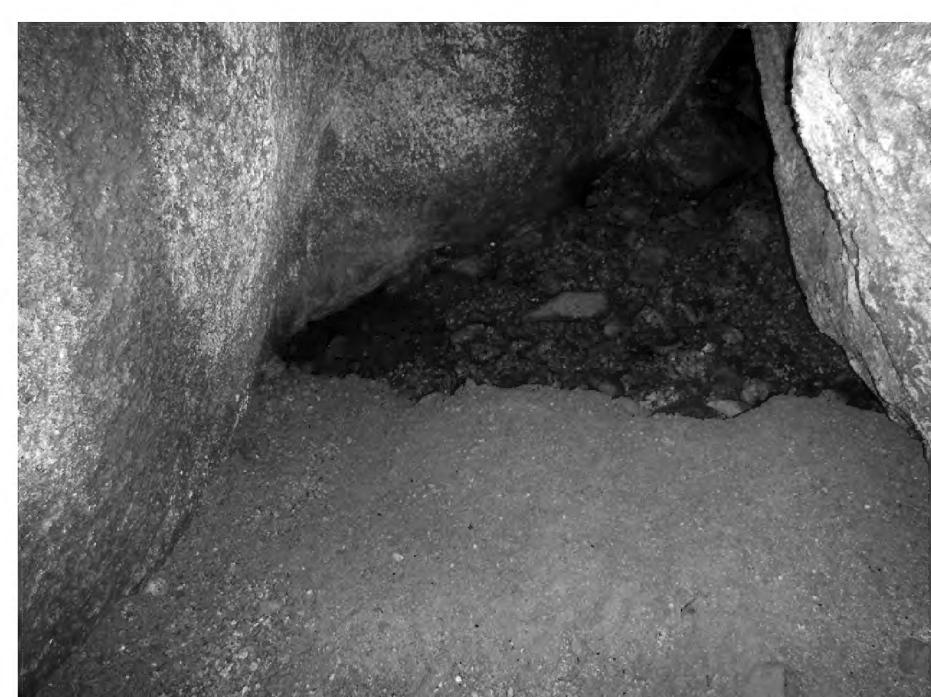


Figure 10. Gruta do Saco Grande, Florianópolis, Santa Catarina state, Brazil. Photo by J.E. Gallão.

comm.) located in the same area as Caverna Laje Branca. A small preserved stream crosses the main cave gallery. The cave has no touristic visitation and is inserted within the boundaries of the Parque Estadual Turístico do Alto Ribeira (PETAR). There is no apparent threat to its fauna.

Gruta do Saco Grande (-27.3922° , -048.4144° ; Fig. 10) is a granitic cave (igneous rock) located in the Santa Catarina Island, Florianópolis municipality, Santa Catarina state. The cave has less than 100 m of passageways and is under a marked influence of the epigean environment (light, organic matter carried by floods). Some threats are observed in the surrounding of the cave, mainly due to the urban expansion, which causes impacts to the small drainage that crosses the cave.

Results

Family Gerridae

Subfamily Charmatometrinae

Brachymetra albinervus (Amyot & Serville, 1843)

Figure 11A

New record. BRAZIL – Mato Grosso • Nobres, Duto do Quebó; -14.4447° , -056.0195° ; 23.IX.2015; M.E. Bichuette, A. Chagas-Jr., D.M. von Schimonsky leg.; 2 ♂, 1 ♀, LES-27727.

Identification. Our specimens were identified based on the antennomere I shorter than II + III; the eye not surpassing the anterolateral angle of the pronotum; the rounded apex of the pronotum; the dorsum of the acetabula covered with silvery setae; and the fore femur robust, slightly arched, with sparse conical black setae ventrally (Cordeiro 2017).

Habitat. Specimens were collected in lentic waters of a medium-sized cave stream, with the bottom formed mainly by sandy substrate associated with organic matter, and low depths, between 0.2–0.3 m. This species is very common in South American streams (Cordeiro 2017), and its wide distribution indicates a troglophilic status (facultative cave inhabitant).

Subfamily Cylindrostethinae

Cylindrostethus palmaris Drake & Harris, 1934

Figure 11B, C

New records. BRAZIL – Bahia • São Desidério, Gruta do Catão; -12.36860 , -044.8676° ; 27.VIII.2008; M.E. Bichuette leg.; 2 ♂, 1 ♀, LES-0011579 – Mato Grosso • Nobres, Duto do Quebó; -14.4447° , -056.0195° ; 23.IX.2015; M.E. Bichuette, A. Chagas-Jr., D.M. von Schimonsky leg.; 1 ♂, LES-27728.

Identification. Our specimens were identified based on the body shorter than 20 mm; the mesonotum of the apterous form with a pair of longitudinal black stripes, each as wide as the median yellow stripe; the black fore tibia; the basolateral processes of the male proctiger subequal in length and width; and the apex of the female

abdominal tergum VIII acute (Florianó et al. 2016).

Habitat. Several specimens of *C. palmaris* were observed along the cave river in Duto do Quebó, especially in lentic sections close to the margins. The river is formed mainly by sand, pebbles, and a huge amount of organic matter (trunks, branches, leaves), with depths ranging from 0.2–0.3 m. It is probably a troglophilic species. At Gruta do Catão, the individuals were in pools with influence from the epigean environment; the pools were 0.30 m deep, and the bottom was formed mainly by silt and a little amount of organic matter.

Family Veliidae

Subfamily Microveliinae

Microvelia ioana Drake & Hottes, 1952

Figure 12E, F

New records. BRAZIL – Santa Catarina • Florianópolis, running water; -27.3922° , -048.4144° ; 01.V.2016; M.E. Bichuette leg.; 1 ♀, LES-11710 • Florianópolis, Gruta do Saco Grande; -27.3922° , -048.4144° ; 30.IX.2016; M.E. Bichuette leg.; 1 ♂, 3 ♀, LES-11704.

Identification. Our specimens were identified based on the general brownish color; the pronotum of the apterous form almost completely covering the thorax dorsally; the proepisternum without conical black setae; the female laterotergites reflected over the mediotergites, but widely separated medially; and the symmetrical male parameres (Magalhães et al. 2021).

Habitat. Several individuals of *M. ioana* were observed in small pools in the drainage with ca. 0.20 m of depth and bottom composed mainly by pebbles and organic matter.

Subfamily Rhagoveliinae

Rhagovelia henryi Polhemus, 1997

Figure 11D, E

New records. BRAZIL – São Paulo • Iporanga, Caverna Laje Branca; -24.5492° , -048.7208° ; 02.VIII.2013; M.E. Bichuette, J.E. Gallão, C.S. Fernandes, P.P. Rizatto, R. Fonseca-Ferreira leg.; 1 ♀, LES-27732 • Iporanga, Caverna Paçoca; -24.5658° , -048.7167° ; 02.VIII.2013; same collectors; 1 ♂, LES-27730.

Identification. Our specimens were identified based on the body uniformly orange-brown, between 4.50 and 5.00 mm long; the pronotum of the apterous form completely covering the mesonotum; the spines of the male hind trochanter not organized in rows; the male hind femur with about 20 short spines at the proximal third; the female hind femur without spines; the hind tibia with the apical spur straight; the abdomen of the apterous female with a median carina dorsally; the male abdominal mediotergite VII with a shiny triangular mark centrally; and the posterolateral margins of the male abdominal segment VII without robust black denticles (Polhemus 1997; Moreira et al. 2010).

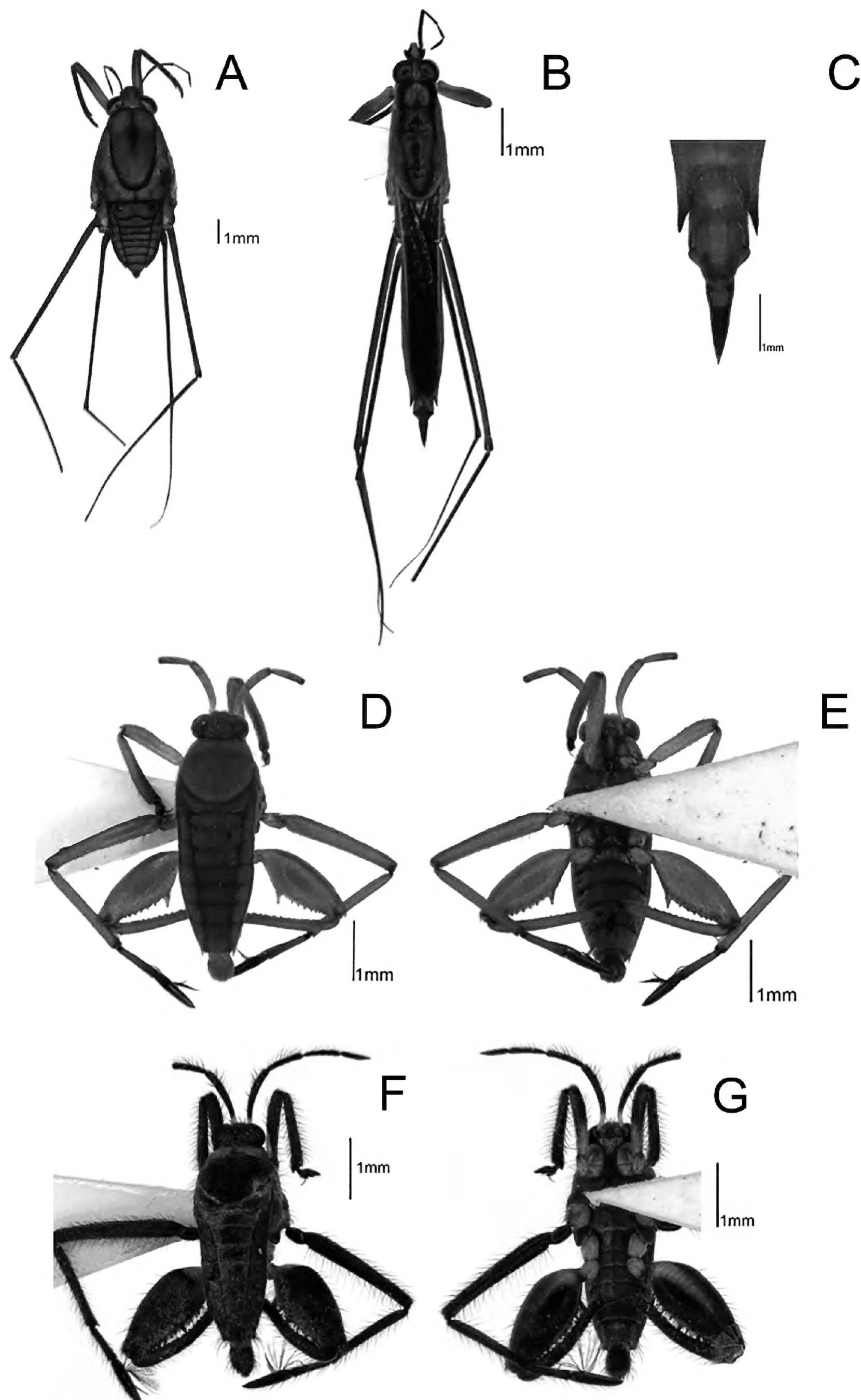


Figure 11. Specimens of semiaquatic bugs collected in Brazilian caves. **A.** *Brachymetra albinervus*, apterous female, habitus, dorsal view. **B, C.** *Cylindrostethus palmaris*, macropterous male. **B.** Habitus, dorsal view. **C.** Apex of abdomen, ventral view. **D, E.** *Rhagovelia henryi*, apterous male, habitus. **D.** Dorsal view. **E.** Ventral view. **F, G.** *Rhagovelia robusta*, apterous male, habitus. **F.** Dorsal view. **G.** Ventral view.

Habitat. *Rhagovelia henryi* is herein recorded from two caves located in the same karst area (Alto Ribeira) and region (Lajeado). The abundance was not high and the specimens were always swimming on the surface of lentic and shallow waters, with the bottom formed mainly by silt. It seems that these conditions are associated with more preserved microhabitats, and streams in both caves have no apparent impact.

***Rhagovelia robusta* Gould, 1931**

Figure 11F, G

New record. BRAZIL – Mato Grosso • Nobres, Duto do Quebó; -14.4447° , -056.0195° ; 23.IX.2015; M.E. Bichuette, A. Chagas-Jr., D.M. von Schimonsky leg.; 1 ♂, LES-27729.

Identification. Our male specimen was identified based on the body between 4.50 and 5.00 mm long, mainly brown to black, contrasting with lighter areas on the anterior portion of the pronotum and on abdominal laterotergites; the jugum and the adjacent portion of the proepisternum with small black denticles; the pronotum of the apterous form completely covering the mesonotum; the hind trochanter with several subequal spines; the hind femur with 3 or 4 irregular rows of spines, with a large spine near the middle dorsally displaced from the others; the hind tibia with a large, conical, preapical spine and a straight apical spur; and the posterolateral margins of the abdominal segment VII without robust black denticles (Polhemus 1997; Magalhães et al. 2016).

Habitat. *Rhagovelia robusta* coexists with *Cylindrostethus palmaris* at Duto do Quebó and was also observed along the cave river in lentic places close to the margins. Interestingly, several juvenile specimens and copulating couples were observed during the collecting event, indicating a troglophilic status for this species.

***Rhagovelia whitei* Breddin, 1898**

Figure 12A, B

New record. BRAZIL – Minas Gerais • São Roque de Minas [sic] [Piumhi], Gruta do Tesouro; -20.3655° , -046.2025° ; 14.VIII.2014; T. Zapon leg.; 1 ♂, LES-27731.

Identification. Our male specimen was identified based on the body between 4.00 and 4.50 mm long, mainly brown to black, contrasting with lighter areas on the anterior portion of the pronotum and on abdominal laterotergites; the pronotum of the apterous form completely covering the mesonotum; the hind trochanter with a single long spine, larger than any of the spines of the hind tibia; the hind femur enormously incrassate; the hind tibia with the apical spur straight; the venter of the body densely covered by black denticles, except for major portions of meso- and metacatabula; and the posterolateral margins of the abdominal segment VII with robust black denticles (Polhemus 1997; Moreira et al. 2012).

Habitat. Specimens were observed in lentic waters along the cave stream, always swimming on the water surface and close to the margin. The bottom was formed

basically by sand and silt, and the depth was very low (ca. 0.1–0.2 m). We observed a high abundance, which indicates a troglophilic status for this species.

Subfamily Veliinae

***Paravelia digitata* Rodrigues & Moreira, 2016**

Figure 12C, D

New record. BRAZIL – Bahia • Central, Toca de Candeias; -11.0533° , -042.1158° ; 18.VIII.2015; M.E. Bichuette, M.J. Rosendo, R. Moreira leg.; 3 ♂, 2 ♀, LES-CT-028.

Identification. *Paravelia digitata* is readily identifiable by the pronotum with a distinct upward directed process at the apex, which is unique in the genus. Additionally, the body is brown to dark brown, between 5.00 and 5.50 mm long; the venter of the head, the prosternum, abdominal sterna III–IV, and the male abdominal segment VIII bear small black denticles; the male hind femur has a row of spines; and the posterior portion of the male sternum VII has a pair of nodules (Rodrigues and Moreira 2016a).

Habitat. *Paravelia digitata* was observed only in small water pools formed by floods or by phreatic authochthonous water, located in the distal part of Toca de Candeias. Individuals were observed in the aphotic zone of the cave and showed frenetic activity in the water surface when aimed at with the lamp light. It is certainly a troglophilic species, at least in a local context.

Discussion

Brachymetra albinervus is the most widespread species of its genus, being recorded from Guatemala to Paraguay and southeastern Brazil (Frauenfeld 1867; Drake and Harris 1930, 1942). Its representatives are usually collected in partially shaded streams with rock, gravel, or sand at the bottom, and had only been recorded from caves once (Monte and Bichuette 2020). The record presented here fills a distributional gap at the northern edge of the Paraguay Basin in Mato Grosso. Previous records from the state are restricted to its eastern portion, in the Tocantins-Araguaia basin (Nieser 1970; Dias-Silva et al. 2013; Giehl et al. 2015).

Cylindrostethus palmaris is the only Neotropical representative of its genus to display wing polymorphism, with apterous and macropterous individuals. This probably correlates with the wide geographical area occupied by this species in South America, whereas its monomorphic apterous congeners are restricted to the northern portion of the continent (Floriano et al. 2016). The habitat preferences of *C. palmaris* are similar to *B. albinervus*, but the former is usually found on faster flowing areas of the streams. It is herein recorded for the first time from a cave, which is located in southern Mato Grosso. *Cylindrostethus palmaris* is widespread in the state, but most previous records are concentrated in its eastern portion (Nieser 1970; Fernandes and Wanzeler 2010; Moreira and Campos 2012; Dias-Silva et al. 2013; Floriano et al. 2016; Dias-Silva et al. 2020).

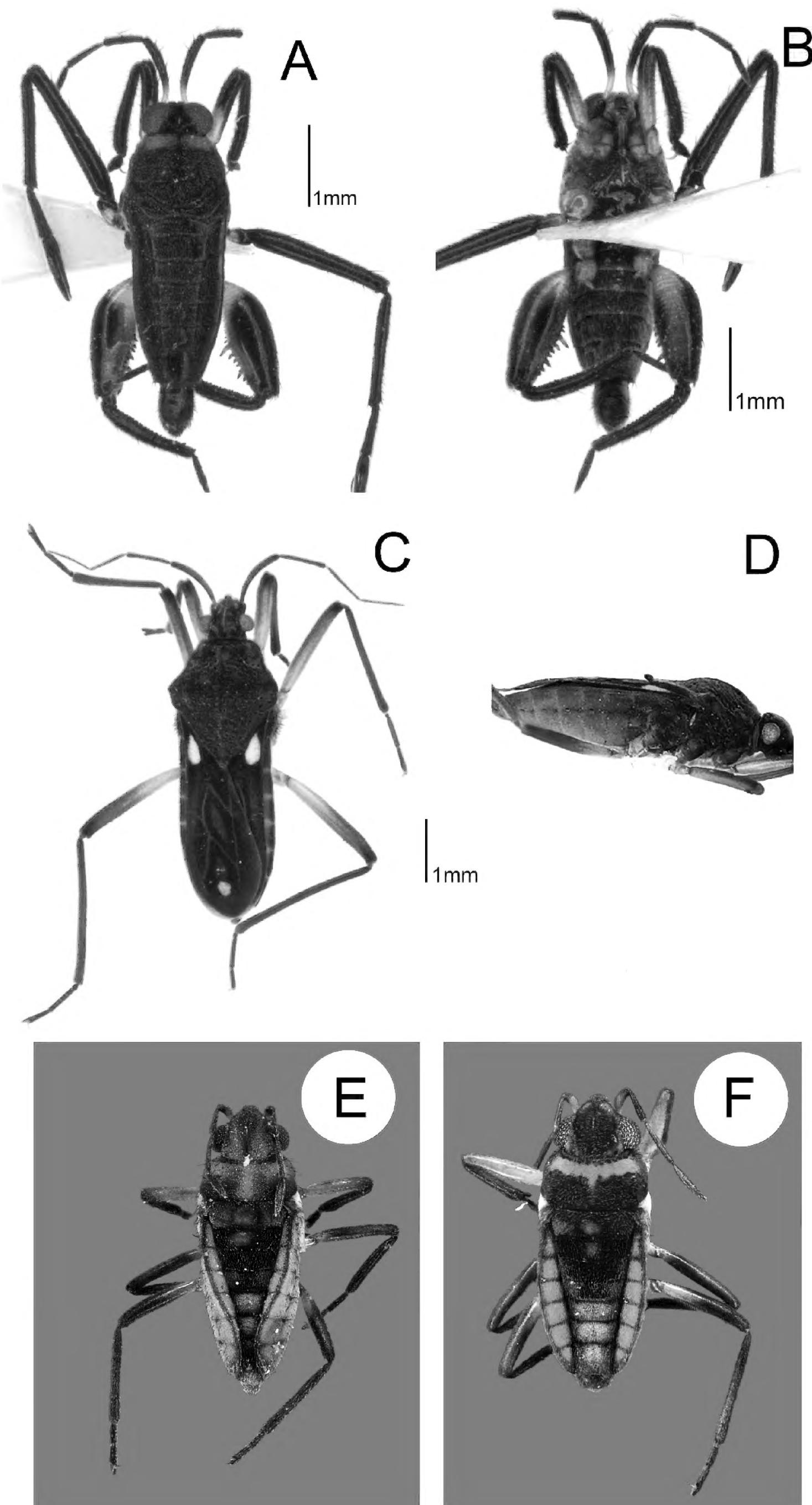


Figure 12. Specimens of semiaquatic bugs collected in Brazilian caves. **A, B.** *Rhagovelia whitei*, apterous male, habitus. **A.** Dorsal view. **B.** Ventral view. **C, D.** *Paravelia digitata*, macropterus male, habitus. **C.** Dorsal view. **D.** Lateral view, anterior portion of head and apex of abdomen omitted. **E, F.** *Microvelia ioana*, habitus, dorsal view. **E.** Female. **F.** Male.

Microvelia ioana is endemic from Brazil, with previous records restricted to central-western Rio de Janeiro state and eastern São Paulo state (Drake and Hottes 1952; Moreira and Barbosa 2011; Moreira et al. 2012). The records presented here are the first from caves and extend the distribution of the species more than 600 km to the south.

Rhagovelia henryi, part of the *R. hirtipes* species group sensu Polhemus (1997), is fairly common in streams and rivers of the Serra do Mar mountain range in southeastern Brazil (Polhemus 1997; Moreira and Barbosa 2011; Moreira et al. 2012). It had already been reported from Iporanga municipality (Moreira and Barbosa 2011), like the material presented here, but had not yet been recorded from caves.

Rhagovelia robusta, part of the *R. robusta* species group sensu Moreira et al. (2012), is widespread in central and eastern Brazil, and also recorded from Paraguay and northern Argentina (Gould 1931; Polhemus 1997; Moreira and Ribeiro 2009; Moreira et al. 2010; Moreira and Barbosa 2011; Moreira and Campos 2012; Dias-Silva et al. 2013). Like *Brachymetra albinervus*, its previous records from Mato Grosso state are restricted to the Tocantins-Araguaia basin (Dias-Silva et al. 2013, 2020; Giehl et al. 2018), more than 400 km northeastward from our new record. This species had already been reported from a cave by Taylor and Ferreira (2012) (as *Rhagovelia pachymeri* Nieser & Melo, 1997, a junior synonym).

Rhagovelia whitei, part of the *R. whitei* group sensu Moreira et al. (2012), is also common in central and eastern Brazil, but is almost completely replaced by the closely related *R. scitula* Bacon, 1956 in the Atlantic Forest (Breddin 1898; Drake and Harris 1931; Polhemus 1997; Castanhole et al. 2012; Moreira and Campos 2012; Floriano et al. 2013; Cordeiro and Moreira 2015). This is the first record of the species from a cave, as well as from the Serra da Canastra mountain range in southwestern Minas Gerais State.

Paravelia digitata was recently described and so far exclusively found in caves. It was previously known from extreme western, São Francisco valley, and south-central mesoregions of Bahia state, with a disjunct record from southwestern Rio Grande do Norte state (Rodrigues and Moreira 2016a). The record presented here is from north-central Bahia, in a gap of more than 1000 km between São Desidério (Bahia) and Martins (Rio Grande do Norte), from where the species had been previously recorded.

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Authors' Contributions

Conceptualization: FFFM. Formal analysis: OMM, IRSC. Data curation: FFFM. Funding acquisition: MEB, FFFM. Project administration: MEB. Resources: MEB. Supervision: FFFM. Visualization: OMM, MEB. Writing – original draft: OMM. Writing – review and editing: IRSC, MEB, FFFM.

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